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# INFORMATION ON THE BIOLOGY AND SURVIVAL OF SALMON OF THE KOLA PENINSULA

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Tables and Figures are omitted.

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The abundance of salmon in rivers of the Kola Peninsula is subject to considerable fluctuations. In the last 25 years their catches have varied between 2.0 and 7.4 thousand centners [200-740 metric tons]. After playing a major role during the period of settlement of our northern regions, the salmon industry even today has an important role in the economy not only of individual cooperatives, but also of whole regions of the northern provinces and especially the Tera and Saama regions of Murmansk province.

For future rational organization of the salmon fishery as a major successful industry it is necessary to pursue the following objectives: [1] continuation of the study of the conditions for salmon reproduction, their migrations, behaviour and so on, and [2] determination of the permissible removal of fish from the spawning populations.

Achievement of the second objective above is especially important, since it would make possible the development of fully effective measures to regulate the fishery. Now a determination of maximum permissible removal from the spawning stock is possible if we know the coefficients of return of adult migrants from a known number of spawners, the total survival rate, and the survival to a second migration. To get these data we need a census of the adult fish caught and of those escaping to the spawning grounds, and a study of the age and sex composition of the spawning populations. To this end PINRO and Murmangosrybvod together have conducted observations on the Tuloma, Kola and Kolvitsa Rivers. In 1958 fish check points were established also on the Zapadnaia Litsa, Ura and Varzuga Rivers. In future the network of check points will apparently be extended, and the large group of ichthyologists of Murmangosrybvod will work toward the desired goals.

At PINRO studies of salmon biology and the salmon fishery were begun in 1943 on the Lower Pechora River by Professor M. P. Somov. However this work consisted only of making large systematic collections for subsequent age analysis. Starting in 1950 a group of PINRO workers under the leadership of I. I. Lagunov has been occupied in learning the efficiency of natural propagation of salmon of the same stocks as those whose abundance is being checked by Murmangosrybvod.

Scale collections provide the material from which we can determine the age composition of the stocks and year-classes of salmon.

On the Lower Pechora ichthyological material was collected by L. I. Vasilev (1943) and S. V. Bondarchuk (1944-1952). In 1953 and 1954 collections of scales were made by local observers. At the fish check points (Kola, Tuloma, Kolvitsa) ichthyological material was also collected by local observers, by Senior Laboratory Technician S. V. Bondarchuk and by the author.

[Page 6] On other rivers of the Kola Peninsula materials were collected principally by Murmangosrybvod workers. Starting in 1958, collections of materials on salmon of the Tuloma stock were made entirely by Murmangosrybvod.

The extensive materials collected on the Lower Pechora have been worked over mainly by PINRO scientist N. M. Somov. Material collected there in 1951 and subsequently has been studied by the author and S. V. Bondarchuk. We have also worked on all the salmon material from the Kola, Kolvitsa and Tuloma Rivers. Material from other Kola Peninsula rivers has been studied by the author, by PINRO Associate Scientist E. L. Bakshtansky and Senior Laboratory Technician S. V. Bondarchuk and Murmangosrybvod ichthyologist M. G. Livshitz.

In computing the relative percentages of different age-groups in the stocks migrating to spawn in rivers being checked, we took into consideration the ratio of the age-groups in each ten-day period of the run, and the number of fish that went up to spawn, and those that were caught, during each such time interval.

In all the tables showing the age composition of the migrating stock or of the individual year-classes, the symbol "+" designates rarely-occurring fish belonging to the age-group in question, while "-" indicates their absence from the sample.

For determining the abundance of the migrating adult stock, we have used only the official data on catches and spawning escapements, not taking into consideration the unavoidable losses which, according to the testimony of fishermen and fishery inspectors, can comprise an appreciable portion of the stock. At the present time our purpose has been to give a concrete picture of the results of natural reproduction under existing conditions, so that it will be easier to judge the effectiveness of any measure that may be taken to improve reproduction.

Materials on the young fish were collected by the author and Senior Laboratory Technician N. A. Ksenzov; in our field studies we repeatedly visited both the main portions and the tributaries of the rivers being checked.

All the statistical data, and all data on the number of spawners going up the Tuloma and Kolvitsa Rivers, were taken from the yearly records of Murmangosrybvod, while the data of Tables 1 and 2 are from the records of the Kola Expedition. Information on the number of young salmon released by the Taibol Hatchery, on the abundance of the Kola stock, and also the data in Table 36 are taken from the annual records of the Taibol Fish Hatchery.

The author is responsible for the final organization and assessment of these materials on the salmon of the Kola Peninsula rivers.

## A short description of the rivers on which census work has been done

We will give a brief description of the rivers on which Murmangosrybvod has begun census work, for the first time in the north. It will also be useful to give some historical information on the fishery in these waters.

The Tuloma, Kola and Kolvitsa Rivers, like most of those in the Kola Peninsula, are of the lake type, their courses being broken up by a series of large and small lakes. They have rapid sections, which can be regarded as connections between lakes or lake-like expansions of the channel. In places where crystalline rocks cross the course of the river, rapids and waterfalls are developed.

The Kolvitsa River has its origin at the southwestern end of Lake Kolvitsa and empties into Kolvitsa Bay of Kandalaksha Gulf of the White Sea. The length of the river is about 9 km, and its width from 20 m (rapids) to 100 m (quiet reaches). [Page 7] The banks are raised, and high in places; the overflow area of the flood-plain is inconsiderable, but at low water level a considerable part of the stony channel goes dry.

Two rather large tributaries enter the Kolvitsa -- the Chernaia and Belaia Rivers, and a number of small brooks with extremely steep courses. The tributaries of the Kolvitsa River and Bay are not used by adult or young salmon.

At 2 and 5 km from the mouth of the Kolvitsa there are two waterfalls. The upper one is passable to salmon at any water level, but the lower one, which was developed during artificial construction of a bypass channel in the Kolvitsa when its course was straightened in the interests of log driving, is not easy for them.

In 1948, when the second bypass in the river was flooded by the dam of a Cooperative's hydroelectric station, Murmangosrybvod constructed an artificial channel with wooden baffles, each of which extended across the channel not quite as far as the opposite bank, and which were arranged in a chess-board array. At the upper end of the channel a control basin was installed in 1949, for counting the adults going up to spawn.

The principal spawning place of salmon is 3-6 km from the mouth of the Kolvitsa. Salmon very rarely enter Kolvitsa Lake or its two tributary streams, the Tiksha and Bolshaia. From 1949 to 1958 only 4 salmon in all were caught in Kolvitsa Lake, although it is rather heavily fished. All these fish had already spawned, and hence it is quite possible they ascended to the lake from the river.

Since 1953 the flow of the Kolvitsa River has been regulated in the interests of log driving, which causes very abrupt changes in water level while it is going on. Since the places inhabited by young salmon are in the rapids sections of the Kolvitsa, frequent changes in level naturally affect their existence. It is possible that the young fish have to repair to the quiet reaches from time to time, where there is greater danger of their being attacked by predators.

Salmon are caught in Kolvitsa Bay, which runs rather deeply into the coastline. We may assume therefore that the fish caught there consist mainly of the Kolvitsa stock. A census of fish caught in the Bay and entering the Kolvitsa to spawn shows the abundance of catch and escapement, while yearly collections of ichthyological material tell us the abundance of individual year-classes produced by a known number of spawners.

Data have not been preserved concerning the salmon fishery near the end of the last century and early in the present one.

In 1920, according to V. V. Nikolsky [18], about 90 poods [1440 kg] of salmon were caught in Kolvitsa River and Bay, or 350-400 fish.

In 1935, according to V. Ya. Persiianov's information, 48 centners [4800 kg] of salmon (1000-1200 fish) were taken, and in 1936 41 centners (900-1000 fish).

In 1945 the post of Fish Guardian was established on the Kolvitsa. Because one of the bypass channels that the salmon had to use to get up to spawn was obstructed with wood and had grown shallow, while the other ended at an impassable waterfall, in 1945 and 1946 adults were caught in sacks and were put into the river above the falls. In 1947 the bypass, which had become plugged with wood, was cleaned out, and spawners were able to get to the spawning grounds without hindrance. In 1948 the cleared bypass was flooded by the hydroelectric dam.

The Tuloma River flows from Notozero [a lake] and empties into Veresova Bay of the Kola Gulf of the Barents Sea. Along almost all of the Gulf a distinct current can be observed. At times of falling tide and with a south wind [page 8] the water becomes fresh for 6 km from the mouth of the river. The length of the whole water system is 290 km, of which the upper part (as far as Notozero) is called the Noto River. The Tuloma River proper runs from Notozero to where the river enters Veresova Gulf near the settlement of Murmashi.

Prior to the construction of a hydroelectric station on the Tuloma in 1936 the spawning places of salmon were in the river itself and in more than 20 of its primary and secondary tributaries. After closure of the river by the dam almost all the former spawning area in the main river was in the flooded zone.

Table 1 shows the principal tributaries of the Tuloma watershed. Salmon enter all the rivers listed in small numbers, but at the present time the Shovna and Ulita are of greatest importance for spawning. Available observations indicate that spawning occurs throughout the whole of these rivers and their tributaries.

The Kola River has its origin in Kolozero and empties into the Kola Gulf. The whole water system is 130 km long, of which the Kola comprises 85 km. Kolozero is joined to Pulozero by a rapid section about 4 km long. Pulozero is about 12 km long, and its greatest breadth is 950 m. From Pulozero a 6-kilometre stretch of river extends down to Murdozero, a lake 11 km long. Below the lake the width of the river in the rapid sections is no more than 70-75 m, locally narrowing to 25 m; in quiet reaches it broadens to 100 m and more. The bottom in the quiet reaches is mainly sandy, while in the rapids it is stony, with boulders emerging from the water. The more important tributaries of the Kola are listed in Table 2.

[Page 9] Spawning places of salmon are distributed throughout the whole basin of the Kola from its mouth up to the brooks that enter the uppermost lakes. The principal spawning sites are in the Kola River proper from the Shonguĭ rapids to the mouth of the Medved River [Bear River] and in the tributaries Kitsa and Medved.

The great extent of the Tuloma and Kola River systems, and the large size of their tributaries, apparently explains the abundance of salmon for which this region formerly was noted. In the 17th century [29] in the vicinity of Kola village about 4000 centners of salmon were caught yearly, that is, about as many as are taken today in an average year in the whole province [oblast].

The rapacious fishery practiced during the last century and at the beginning of the present one, in Kola Gulf and in all the rivers emptying into it [31, 32], could not help affecting its salmon stocks. According to the data of Soldatov [31, 32], at the end of the last century and beginning of this one, the following quantities of fish were caught in Kola Gulf in the Paluna region:

| Year | 1898 | 1899 | 1900 | 1901 | 1902 |
|---|---|---|---|---|---|
| Catch, centners | 457 | 664 | 316 | 294 | 149 |

The above does not include the catches of the Kola, Ulita and Shovna Rivers, in which weirs were also operated, or those of the Tuloma and Paduna Rivers off their mouths, where lokh [male salmon] alone were taken in quantities up to 88 centners in years of good catches.

According to N. S. Ovsîannikov's [23] data, before the first world war the Kola region provided up to 420 centners of commercial salmon, after which time the catch declined.

| Year | 1916 | 1926 | 1927 | 1928 |
|---|---|---|---|---|
| Catch, centners | 416 | 365 | 143 | 165 |

Between 1944 and 1957, from 96 to 227 centners of salmon a year were caught, but catches greater than 200 centners were taken only twice during this period -- in 1947 and 1948.

Marine migrations of salmon [page 19]

Our knowledge of the ocean period of life of the salmon, the places they feed, and their marine migrations, is still inadequate. The reason is that the attention of investigators has always been centered on studying the freshwater period of the salmon's life, since the numbers of all anadromous salmons depend mainly on conditions for their reproduction. In addition, until recently no sea fisheries existed in the regions where young salmon forage or along their spawning migration routes. Even now, in spite of the rapid development of the herring and trawl fisheries, knowledge of the sea life of salmon is accumulating very slowly, because of the small numbers of salmon and the slight probability of them being taken in sea-fishing gear.

The present position would change if a sea fishery for salmon were to develop, but we cannot count on this, because there is as yet no reason to believe that salmon form schools of commercial size in the open sea. Rare instances have been noted of 10 to 15 small fish (30-45 cm long) being taken in herring drift nets in the open part of the Norwegian Sea [page 20], and even more rarely single specimens of large salmon are taken. A salmon fishery on the high seas cannot be regarded as desirable anyway, because the important habit that salmon have of returning to their native river makes it possible to utilize individual stocks in a planned fashion.

During the last 22 years (up to 1956) salmon catches in rivers of the Kola Peninsula have been relatively stable. It is evident that during this period the effect of the fishery and of the regulatory authorities have provided an escapement of spawners sufficient for the conditions of reproduction. If a sea fishery were to begin, this equilibrium would of course no longer be in balance, and it could not be preserved.

Not so long ago it was believed that when young salmon went to sea they foraged in the neighbourhood of the mouth of their native river. However, in 1935 salmon were caught in the Vyg River which had been tagged off the west coast of Norway [2]. In 1957 fish tagged in Norway were again caught at several marine fishing sectors of our northern seas and in many rivers. P. G. Danilchenko [8] has shown that cases of captured salmon tagged by the Norwegians have been reported from almost all the principal fishing regions of the North in the USSR. Since the return of salmon to spawn in the same rivers as they were hatched in, and from which they went to sea, is today no longer in dispute, we must regard the migration of our salmon to the Norwegian Sea as a demonstrated fact.

After going down to sea, young salmon remain for some time in the pro-estuarine region, then take off for more distant places. Danilchenko [8] believes that young salmon of the rivers of the Tera coast stay near the mouths of their native rivers for several months, and only move off in the direction of the mouth of the White Sea in autumn after they are 25-30 cm long.

For some part of the young fish this is undoubtedly true, because we know 4 cases of the capture of young salmon -- 19.5, 21, 21 and 24 cm -- in Kandalaksha Gulf between the 10th and 25th of August 8 or 9 km off the mouth of the Niva River. These fish had 6 to 8 sclerites of sea growth on their scales. In addition, I know of an instance of the capture of a young salmon in June in Bolshaia Lopatka Bay. In August 1959 in the region of Cape Turia in the White

Sea two salmon were caught, of 24.4 and 23.3 cm, and 141 and 147 grams. They had 11 and 13 sclerites of sea growth.

However, a lot of observations indicate that a considerable part of the young fish apparently do not stay very long in the neighbourhood of their natal river. This is shown by the occasional capture of young salmon in the herring weirs along the Tera coast. In 1950 E. G. Kossov and L. V. Gribanov, students at Mosrybvtuz, brought to PINRO 156 specimens of smolts taken along with herring during the second half of July in the White Sea east of the mouth of the Varzuga River. According to G. D. Gromov, the schools of young salmon present in the bay of the Chavanga River are very considerable; this precludes the possibility that these fish had only just left the Chavanga River.

Danilchenko's [8] data show that in autumn young salmon move along the Tera coast eastward, reach the mouth of the White Sea and escape through it. R. S. Semko [27], who studied the biology of Pacific salmon, came to the conclusion that coastal feeding grounds must be considered as only temporary stopping places: with the drastic cooling of coastal waters in winter, salmon beetle off to more distant and warmer parts of the sea. Thus the connection between fresh waters and marine feeding grounds is broken in winter, and hence we positively cannot postulate [page 21] the existence of year-round feeding grounds in the White Sea.

Danilchenko [8] indicates that an autumn movement of salmon in a westerly direction has also been observed along the Murman coast. I know of only 2 instances of the capture of young salmon in the Barents Sea in autumn; one individual (26 cm long) was captured in September, 1949, near Kildin Island (the date of capture and direction from the Island are not known) while the other (27 cm long) was captured October 19, 1953, 25 miles north of Cape Teriberka. There were 12 and 16 sclerites of sea growth, respectively, on the scales of these fish. Both specimens were captured in drift nets.

Individual specimens of adult salmon are captured rarely in the Barents Sea in the trawl fishery. I know of 2 instances of the capture of salmon 72 and 78 cm in the region of the Kola meridian in June and July, at depths of 100 m, one instance of the capture of a salmon in July north of Cape Sviatoi Nos at a depth of 135 m, and 3 instances of their capture to the north and east of Kolguev Island between September 9 and October 17 at depths from 82 to 155 m. In addition, there is an example of the capture of a salmon in the Kola Gulf in the region of the town of Poliarnyi on April 24, 1956. Thus, in spite of the presence of a year-round fishery, on the high seas and in the coastal part of the Barents Sea, all known instances of the capture of salmon fall within the period from April 24 to October 19.

In recent years, thanks to the development of the USSR's drift net fishery on the high seas, new information has been obtained on the distribution of salmon. For example, in Region A (Fig. 2) we have information about the capture of 87 specimens of small salmon 30 to 45 cm in length, and 9 larger specimens 60 cm and longer. One of the larger specimens weighed 4.3 kg, which corresponds to a length of 72-75 cm. The rarity of the occurrence of large salmon is apparently explained by the size of the nets used in herring fishing.

[Page 22] In June 1959 near Bear Island 3 salmon were caught, 79, 81, and 83 cm long, while on September 9 northward from the Rybachi Peninsula a salmon 29 cm long was caught, age 3+ years, with 12 sclerites of sea growth.

Examination of the scales from 31 small salmon taken from Region A in August, September and October shows that these were fish which had gone to sea during the current year. They had 6 to 28 sclerites of sea growth. Fifteen of these fish were age 2+, 13 were 3+, and 3 were 4+. Fish 42 and 45 cm long, caught in this region in April, already had winter contraction along the scale margin.

Data on the increase in weight of salmon during their first year at sea, in relation to length, are given in Table 15.

Thus for Region A we have captures of salmon during August, September, October and April. North of the Faroes Island in Region B (Fig. 2), 4 salmon were captured in March. This information leads to the hypothesis that in the Norwegian Sea salmon occur all year round, while in the White and Barents Seas (apart from the regions just off the river mouths) they occur only in summer.

At the time of their spawning migrations salmon make long journeys.

At point a (Fig. 2) salmon were tagged which were recaptured in 1935 in the Vyg River, while fish [recaptured in Russian waters] in 1937 had been tagged at point б. According to the Norwegian newspaper "Fiskaren", on July 31, 1957, a salmon tagged in Scottish waters was captured in one of the fjords of Greenland, that is, 1700 nautical miles from the place of tagging. In the northern part of Region A on September 26, 1951, a salmon was caught by a Soviet vessel bearing the Swedish tag No. 5819, which had been attached in southern Sweden on April 21 of the same year (point в, Fig. 2). The length of this specimen when released was 16.5 cm, and when recaptured it was 36 cm. Thus, while moving a long way during the 5 months this salmon had grown by 19.5 cm. On June 20, 1957, a salmon was caught in Norwegian waters weighing 3.2 kg, which had been tagged on July 16, 1955, on the west coast of Sweden at a length of 14 cm.

The facts adduced lead to the hypothesis that in the North Sea and Norwegian Sea salmon feed and grow, while they migrate subsequently to rivers not only of the countries of Europe, but even of Greenland[1]. A confirmation of the fact that salmon of different stocks were caught in Region A is provided by pictures of the scales of the fish living in the sea during their first year. For example, the scale shown in Figure 3a may belong to a fish which left one of the rivers of the Murman coast, whereas the freshwater zone of the scales shown in Figure 3 б, в have a greater similarity to the river zone of the scales of fish caught along the Tera coast (Fig. 4).

[Page 23] On the high seas salmon apparently occur either singly or in rather small schools. This is indicated by the testimony of fishermen who have caught salmon singly and also in groups of up to 15 individuals in a gang of drift nets.

According to the newspaper "Fiskaren", on May 15 in Seresund [Sereĭsund] about 5 tons of salmon were captured in one haul of a purse seine. The school surrounded consisted of large fish weighing 7-8 kg.

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[1][Azbelev evidently thinks this salmon was tagged at a large size and went to Greenland to spawn. My impression was that it was tagged as a smolt, and was probably only foraging in Greenland waters. — W.E.R.]

In October, 1959, a salmon with a Norwegian tag was caught in the White Sea west of Cape Turia, and in July of the same year one was caught in Kola Gulf. The place where they were tagged has not yet been determined.

[Page 26] According to P. Yu. Shmidt's [35] data, there are instances of the capture of salmon at depths of 115-120 m, according to our data they have been captured at 155 m, and according to G. N. Monastyrsky [17] at 140 m. E. K. Suvorov [33] tells of the capture of salmon in winter in the depths of the Sogne fjord. Monastyrsky, citing information from the foreign literature, says that in the open parts of the sea salmon prefer to remain in the surface water layers. This is confirmed by our data; in Region A and Б (Fig. 2) salmon were captured at depths rarely exceeding 10-12 m.

According to L. S. Berg [3], in the sea salmon feed mainly on fish -- herring, capelin, sandlances, and also large crustaceans. In the stomachs of small salmon caught in Regions A and Б (Fig. 2) we found <u>Themisto</u>, in some cases <u>Calanus</u>, and in the stomachs of the larger fish sandlances and herring. Fishermen operating in the Kola Gulf in May have repeatedly told us the same thing. There is similar information in the papers of V. K. Soldatov [31, 32].

Tagging data have shown that at the beginning of their spawning migration the salmon of our rivers come close to the Norwegian coast. The later part of their migration path apparently lies at some distance from the Kola Peninsula, and comes close to shore only in the region of the Umba River and Poria Bay.

If the migration routes ran along the immediate coastline, then the salmon would enter into the bays. In this event considerable difference would be observed not only in the times of the migration of the fish in the bays and in their tributary rivers (which actually does not occur), but there would also be differences in the average weight of the fish caught in the salt-water and freshwater sectors. At the same time, if the migration routes were at some considerable distance from shore, cases of the capture of salmon in trawls and drift nets would not be so scarce.

Table 16 shows that in the Teriberka region and in the region of the Varzuga River there is no significant difference between average weight of salmon caught in the sea and those caught in the rivers, while in the region of the Umba River there is a rather considerable difference. Differences in average weights are also characteristic of salmon caught in the region of Poria Bay.

[Page 27] Consequently we may presume that in the sea westward from Cape Turia, the schools captured are not of the same stock as those which enter the Umba River. In addition, the very fact that a salmon fishery exists in the region of Poria Bay, where there are no important salmon rivers, indicates that the spawning migration routes here run close to the coast.

It is likely that in the Tera region, and in the region of the Varzuga River, salmon come close to shore near the mouths of their native rivers, while in the region of the Umba River and beyond (perhaps even almost to the Kutovaia portion of Kandalaksha Gulf) the stocks are mixed together because of the close approach of the migration routes to shore. Information from tagging done by workers at the Varzuga fish hatchery tends to support this idea; all the tagged kelts were recaptured either in the Varzuga River itself, or close to its mouth, or between the mouths of the Varzuga and Chavanga Rivers, that is, in the general region of the native river.

The main mass of salmon migrating to the rivers of Karelia apparently do not enter very far into Kandalaksha Gulf. If they did so, the catches of salmon in Kandalaksha Gulf would be much greater, and the mortality of the Niva and Kanda stocks would not be a reflection of the fishery there. A small part of the salmon, if not from the Karelian Rivers then in any event from the Kovda River, does enter the Kutovaia portion of the Gulf.

As is well known, the old channel of the Niva River has been dried up for a long time, and the channel into Kanda Bay, by which salmon formerly entered the rivers tributary to it, has been closed off by a dam. Nevertheless, every year salmon come up to the dam and enter a canal by which the tail-race water from the Niva River is discharged. According to fishermen's opinion, salmon are caught in the Gulf in the region of Kanda with marks of the sharp ends of the hooks that poachers use to catch salmon in the canal. One example of such a capture was observed in Kolvitsa Bay. Consequently, it is possible that during the spawning migration period some fish enter the mouths of foreign rivers and remain in them.

The fish caught in the Gulf during 1951-1954, in the region of the old mouth of the Niva and mouth of the canal, differ a great deal in age composition from fish which were caught there in 1930 (Table 17).

## Return and survival rate [page 51]

### [Kolvitsa River]

The first salmon enter the fishway [rybokhod] 2 kilometers from the mouth of the Kolvitsa River during the last days of June. The greatest number of fish arrive in July; in August the run always falls off, and it ends in the first half of September. Observations over 10 years have shown that no salmon arrive at later dates.

We regard the Kolvitsa stock of salmon as an independent one, not mixing to any extent with the neighbouring Lubenga River stock. No autumn salmon [osenniaia semga] enter the Lubenga; its run of summer salmon [letniaia semga] begins approximately half a month earlier than in the Kolvitsa, and it is already over by the first days of August.

Table 57 shows the results of the reproduction of Kolvitsa salmon. Among the autumn fish caught at the beginning of the summer (they can be distinguished from fish of the summer run of the same year by their scales, which show a large increment during the previous summer), one sea year has been added to the years actually represented on their scales. In calculations of the sex ratio and age-groups in the reproductive part of the migrating stocks, fish caught in autumn have not been taken into consideration.

Over the period of observations, the ratio of fish returning to the number of spawners that produced them (males and females) has varied from 1:2.57 to 1:5.00, and total survival rates have varied between 0.05 and 0.09%. This is considerably less than the survival rates for sockeye, [page 53] which Krogius and Krokhin found to vary between 0.14 and 0.26%.

In spite of the low survival rate, the number of migrants returning to the river is up to 5 times the number of their parents; the average ratio for the return of 4 year-classes was 1:4.00. This rather large return at a low survival rate is explained by the great fecundity of the Kolvitsa salmon (as compared with sockeye) and the almost invariable excess of females in the spawning stocks.

The survival of Kolvitsa salmon to return for a second migration cannot be considered good. The gradual decrease in percentage survival [with time] is noteworthy [see the last column of Table 57]. I cannot give a complete explanation of this, but I suggest that the decrease in survival of kelts may be associated with regulation of the river flow for the purpose of log-driving, and also, probably, some catching of spawners out of the river at the time any logs left behind after a drive are cleared out of the river.

Data on the numbers of the year-classes produced in 1953 and later will make it possible to evaluate the effects of log driving.

### [Tuloma River]

Before turning to the question of the return and survival of the Tuloma salmon stock, we must ascertain whether there is really a separate Tuloma stock that does not mix with that of the neighbouring Kola River.

Published data on this point are scanty. N. S. Ovsiannikov [23] compared the rate of growth of the Kola and Tuloma salmon, and put forth the view that they belong to a single stock of fish entering the Kola Gulf. L. M. Nusenbaum [22] apparently took the opposite view. He felt that hatchery reproduction of Tuloma salmon with subsequent release of fry into the Kola watershed must cause a re-direction of schools of Tuloma salmon into the Kola River. In my opinion the existence of two separate stocks is more likely, because the stocks that migrate into the Kola and Tuloma Rivers are sharply differentiated in respect to age and sex composition (Fig. 5), and these differences are quite consistent.

Figure 5 shows that in the Tuloma stock the fraction of 3-year-old fish is always greater than in the Kola, and the fraction of 6- and 7-year-olds, and also of repeat spawners, is less. In the Kola stock, as a rule, females predominate, while in the Tuloma males predominate to a certain extent.

[Page 54] G. Golovkov and N. I. Kozhin [5], after studying 567 fish during the first years of the operation of the fishway, found that 43 (about 7.5%) of them were going up to spawn a second time. Since 1950 the number of fish in the Tuloma stock that are on their second spawning migration has varied from 0 to 2.4%, while in the adjacent open Kola River it has been from 4 to 13.8% (av. about 6%).

According to the observations of P. V. Fomin, an employee of Murmanrybvod, the decrease in percentage survival of repeat spawners can also be associated with altered conditions for downstream migration. A considerable number of silvery kelts collects every year in front of the hydroelectric station and stays there sometimes up to the middle of August. This phenomenon cannot be regarded as normal, because in the neighbouring Kola River the downstream migration of silvery kelts is practically over by July.

According to Fomin, troups of silvery kelts quite often are found in this part of the reservoir, and this has been confirmed by diving done above the dam in July. From the fact that the number of kelts accumulated above the dam gradually decreases, we may also draw the conclusion that part of them move downstream not only through the floodgate but even through the turbines. Golovkov [6] has demonstrated the feasibility of the latter route.

For passing salmon upstream to their spawning places a fishway of the ladder type was designed, consisting of a succession of 57 pools. The height of each step is 0.3 m, and the length of the fishway is 500 m; the height of the ascent is calculated as 20 m. At the upper end of the fishway a vertically movable basin [pod'emnyi sadok] was placed, for exact enumeration of the salmon passing through.

Before entering the inlet opening of the fishway, the fish are concentrated by the flow coming out of the floodgate. The days of their entry from the river, especially in years of abundant water, are prolonged, the sex ratio is somewhat evened out in the course of the run and a considerable part of the adults show clear indications of their spawning colours.

Complete data on passage of salmon in the Tuloma River are shown in Table 58.

In 1948, 1949, 1954 and 1958 part of the fish, not included in Table 58, were removed for fish cultural purposes: respectively 498, 333, 450 and 1300.

Because the [military] front was nearby in 1941-1944, the fishway was opened [only] as occasion permitted. This is the reason for the poor returns in 1946-1950.

Since the main bulk of Tuloma salmon migrate at the ages of 4+ and 5+, by comparing the years of parental migration and spawning with the years of return of fish belonging to these two age-groups, we can see that the years of return of a reduced number of fish correspond to years when there was no control of the passage of spawners (Fig. 6).

[Page 55] Thanks to the fish-census work organized in 1950 on the Kola River, it has become possible to know fairly accurately the number of fish migrating into the Kola and Tuloma Rivers, which includes the catch in the Gulf, the escapement to the Tuloma, and the escapement to the Kola.

Variations in salmon catches in Kola Gulf have not exceeded a range such that the maximum catch is twice the minimum. The abundance of the stock in rivers of the Kola Gulf has varied within about the same limits.

Table 59 shows that the abundance of the Kola stock has gradually declined, and that of the Tuloma stock has increased. I associate this with the greater fishery for adults and young in the Kola watershed.

From 1952 to 1958 the fraction of males in the Tuloma stock migrating up to spawn averaged about 55%. The average fecundity of the Tuloma females during this period was 10,400 eggs. The excess of males in the Tuloma stock is a result of a considerable migration of grilse -- summer fish that have lived a year in the sea, and of which 94-98% are males.

Many practical observers affirm that formerly there were no grilse in Kola Gulf. Some of them refer to the data of A. G. Smirnov [30] for 1929 and 1930, when, in his opinion, not a single grilse was captured. Smirnov's information came from the fishery statistics, hence it does not show that no grilse were caught during those years, but only that none were brought to the fish collection centre.

V. K. Soldatov [31, 32], who always carefully verified and analyzed information obtained from local inhabitants, testifies to the presence of grilse in Kola Gulf [around 1900]. [Page 56] In former years small salmon were not regarded as commercial fish, and the fishermen abstained from fishing at the time of their abundant appearance in the fishery.

N. S. Ovsiannikov [23], on the basis of his observations from 1927 to 1936, considered that the catches of grilse in Kola Gulf and its rivers amounted to 50% of the yearly catch (by weight), and at the same time pointed out that they were not delivered to the fish-collection centres. Consequently in those years a very large number of grilse entered the rivers of the Kola Gulf; and hence the large percentage of fish with one year of sea life, which we observe every year in stocks migrating into the Kola and Tuloma Rivers, must be regarded as quite a usual phenomenon.

Results of the reproduction of salmon of the Tuloma River stock are shown in Table 61. For the year-classes 1945-1950 the average return from a known number of spawners is indicated by the ratio 1:3.97, that is, almost the same as for Kolvitsa salmon. This average ratio characterizes Tuloma reproduction during the period when the migrating stock was increasing in abundance, and consequently it cannot be regarded as a long-term average to be used as a basis for fishery regulation without risk of decreasing the recruitment to the stocks.

Knowing that in the Tuloma River the fraction of males in the migrating stock averages about 45%, and that the average fecundity of the females is 10,400 eggs, the average overall percentage of survival can be computed approximately. For example, from 1945 to 1950 inclusive 7910 adults were put up-river, 3560 of them females, which laid 3560 × 10,400 = 37 million eggs; from these we obtained 31,465 adult migrants, or 0.085% of the original number of eggs.

According to M. N. Melnikova's [13] calculation, the overall survival of the Varzuga stock is 0.12% -- considerably more than the 0.085% for the Tuloma or the 0.065% for the Kolvitsa. I do not regard Melnikova's figure as too high, because with the fecundity of the Varzuga salmon only 4700-4800 eggs, the Varzuga stock could not continue in this way without finally going under, if it had the same survival rate as the Kolvitsa salmon.

[Kola River]

Working out the results of the reproduction of salmon in the Kola River is attended by many difficulties, not only from defects in the data, but also because both natural and artificial reproduction contribute to that stock.

Table 62 shows the results, and it is evident that the abundance of the year-classes of Kola salmon has had a clear tendency to decrease. [Page 59] Some practical observers believe the cause of the decline to be the cessation of importation of eggs from Veresova Gulf. Up to 1950 the Taĭbol Fish Hatchery incubated eggs of the Tuloma stock of salmon, but since 1950 it has shifted to the Kola stock. Thus up to 1950 the Kola stock was supplemented at the expense of the Tuloma.

However the decline in abundance can scarcely be laid to the cessation of egg transfers: this could be so only if the effectiveness of artificial propagation had been very high and if natural propagation had been of little importance. But the role of natural propagation cannot sink to zero. The abundance of the 1946 and 1948 year-classes was approximately the same, although the former received no supplementation from Tuloma stock at all, while the latter was supplemented by the addition of 1.8 million 30-day-old fry.

In the 1930's A. G. Smirnov [29] believed that to obtain catches of 110,000 fish per year (the average catch in those days) in the rivers of the Kola Peninsula it was necessary to have an escapement of about 9000 spawners. This view was based on an overestimate of the reproductive capacity of the salmon. At the same time, the data we have obtained on the total survival of salmon are somewhat too low. In our calculations we have used not the number of spawning fish, but rather the escapement up the river; which of course are not the same, because part of the fish die from various causes, and part are caught.

[Pechora River and Teriberka River]

Without fish-census work we never know the exact abundance of the migrating parent stock and of the broods they produce, but when there is a sharp increase or decline in abundance of salmon a picture close to actuality is provided by catch statistics, considered in conjunction with collections of biological material.

For example, we have such a picture of the abundance of salmon in rivers of Teriberka Gulf, for there biological material has been collected by workers of the Murmangosrybvod, starting in 1950 (Table 63).

As a result of the collection of biological material, similar data are available to us for the Pechora salmon (Table 64).

The data of Tables 63 and 64 are of great interest, for they give some appearance of changes in survival rate. For example, the smallest year-class of Pechora salmon (from the spawning of 1945) was one-sixth as big as the largest, while the Teriberka year-class from the 1945 spawning (also very weak) was about 40% of the 1950 year-class. [Page 60] The 1945 year-class was very weak in the Kola, Tuloma and Kolvitsa stocks.

According to foreign data, the number of adult fish returning to a river amounts to about 10%, on the average, of the number of smolts (this rate of return is used in fish management). Knowing the abundance of the year-classes and the number of eggs in female spawners, we can calculate approximately the loss of eggs and young in the river as a percentage of the total number of eggs.

For 4 year-classes of Teriberka salmon these losses are very imposing: from 99.19 to 99.47%, while for the Tuloma stock (1945-1950 year-classes) they average only 99.1% -- that is, considerably less than in the Kola and Kolvitsa Rivers. This evidently is another result of the rapid growth in numbers of the Tuloma stock in recent years.

A comparatively high survival of salmon of the Tuloma stock is quite natural, because in the Tuloma watershed the spawners, and hence the young, are dispersed among the tributaries. In the Kolvitsa the spawners ascend a maximum of 6-7 km from the mouth, while the young of several ages (three principal ones) are crowded into the sections that have rapids, and whose whole extent is not over 3.5-4.5 km. Consequently the density of population of young fish in the river is quite considerable, especially if we take into consideration that anadromous trout enter the Kolvitsa in numbers amounting to one-third to one-half of the number of adult salmon, and a lot of small trout enter the rapid section of the river from tributaries.

The question of the effect of water level in rivers on survival of eggs and young of salmon has been repeatedly examined in the literature.

An association between average water level during the first year of life of the young fish and their return is fairly clearly indicated in the Kolvitsa River (Table 65). Comparable data for the Tuloma stock did not give any definite result. The reason is apparently that the gauges to measure water level are not situated in the spawning tributaries, but in the main stream below Notozero [a lake], which regulates the flow of the Tuloma.

[Nine-year Cycle]

L. S. Berg [2] showed that for our North a 9- or 10-year cycle of catches could be detected, that is, every 9 or 10 years (in the first half of each decade) the catches of salmon declined abruptly; in a number of cases fluctuations of shorter periods -- 4 or 5 years -- were observed, which apparently reflect the influence of varying year-class strengths.

[Page 61] The later course of the fishery has confirmed the correctness of this conclusion: after 1932 there were small catches in 1942 and in 1951, although the 1951 decline was much less severe than those of 1932 and 1942 -- because it resulted from the low abundance of only one year-class, 1945.

If this periodicity is associated only with conditions for reproduction, then because of their differences in age composition, in some rivers minimum runs would have to be observed earlier, and in others, later. In most cases this does not happen, and the catches decline simultaneously (speaking now of the longer period) throughout almost the whole of the North. Consequently we must consider that in this series of cases we have to deal either with the action of widespread natural factors unfavourable to the survival of young salmon of varied ages in rivers, or else factors affecting the abundance of salmon in the sea.

From Tables 57, 61, 63 and 64 it is evident that the year-class from the 1945 spawning was minimal among salmon of the Pechora River as well as rivers of the Kola Peninsula. L. S. Berg [2] showed that good catches of salmon did not coincide with good catches of other marine fishes. This is undoubtedly so, but I believe that comparison of the catches of different fish can lead to correct conclusions only if the stocks caught consist of the same age-groups. Better results might be given by a comparison of the abundance of individual year-classes of salmon and marine fishes. Berg did not have data arranged in that way, and it would have necessitated his using combined data on catches over broad regions.

Knowing the abundance of the year-classes of certain salmon stocks, we can compare them with the abundance of cod as estimated by A. S. Baranenkova from the average catch of young cod per hour of trawling and the average ratio of the age-groups in the catches. The abundance of year-classes was estimated on a 3-point scale: 1 -- weak; 2 -- average; 3 -- strong. Deviations were represented by the symbols + and -.

Table 66 shows that the year-classes 1945 and 1946 were minimal or very small not only for salmon of the stocks known to us, but also for cod, after which time the size of their year-classes increased. According to PINRO data, the year-classes of haddock and herring were also weak during these years, while the 1950 year-class was abundant among the salmon stocks known to us, and among cod, haddock and herring. Consequently it would be incorrect to believe that the abundance of salmon year-classes always varies independently of that of other marine fishes.

[Page 62] Data on the distribution of age categories among several salmon broods spawned in 1945 make it possible to compare the percentage representation of fish having differing periods of river life in these broods with the long-term average (Table 67).

During the interval of time at hand, only the 1945 broods exhibit such sharp deviations from the long-term average in all these rivers, and the shifts in length of the period of life of the young salmon in the river have many features common to all rivers. For example, there was a sharp increase in the fraction of the fish that lived in the river 2 years, the fraction that stayed 3 years declined, while the fraction that reached 4+ and 5+ increased. These changes were especially marked in the Pechora stock. Thus the 1945 year-class differed from others not only in its low abundance, but also in the length of time the young fish stayed in the river.

[Varzuga River]

Determination of the abundance of the salmon stocks migrating into rivers of the Kola Peninsula and into the Kolvitsa River is considerably simplified by the fact that these rivers empty into gulfs that penetrate far inland. The abundance of the stocks in these cases is the sum of the fish caught plus those that go upriver. It is even easier to know the abundance of stocks that are not fished [before they enter the river], but where all the fish that have entered the river are counted at a weir situated close to its mouth, and of this number a part are taken for examination (Zapadnaia Litsa, Ura).

[Page 63] It is much harder to learn something about the abundance of the stock when a salmon fishery is conducted along a coast on which the mouths of many rivers are situated. Such a fishery catches the stock of many rivers, including the one on which census work is being done. We first encountered this situation in 1958, when an enumeration point was established on the Varzuga River. There are reasons to believe the Varzuga stock is caught at the marine fishing sectors situated on both sides of the mouth of the river. We cannot as yet exactly delimit the region where Varzuga fish are taken, but its approximate limits can be determined from data on tagged kelts obtained by workers of the Varzuga Fish Hatchery, from data on the average weight of the fish caught, and from the percentage distribution of the different [commercial] grades of fish.

The kelts tagged in the Varzuga River are caught on their return migration not only from the Varzuga itself, but also on both sides of its mouth (Fig. 7). The greatest number of tagged fish was caught at the fishing sectors between the mouths of the Chavanga and Varzuga Rivers. One tagged fish was taken west of the mouth of the Varzuga. This comes about because, when the wind blows from the direction of the entrance of the gulf, the fresh water [from the river] is diverted to the west, and this causes the fish to approach the mouth from that side.

The long-term average weights of the salmon caught between Pialitsa and Olenitsa are almost identical.

Statistical data show that in some years up to 10,000 fish are taken in sector No. 27, where there are no salmon rivers, while in sector 26 up to 2000 are taken. If the fish caught here were mainly migrating westward, then their average weight would be close to that of the salmon caught in sectors 23 and 25. Consequently we may presume that in sectors 26 and 27 the fishery takes mainly Varzuga fish. This is confirmed by data on the relative proportions of the different commercial grades in the catches taken in these two sectors (Fig. 8); they agree almost perfectly with the proportions in sector 38, on the Varzuga River.

In the eastern sectors, the difference from sector 38 in proportions of the commercial grades is quite marked. Apparently here we begin to encounter in the catches salmon from the Chavanga, Chapoma and Strelna Rivers, and others. In addition, in Varzuga sector No. 38 and on all parts of the coast from 27 to 44 the greatest catches are always taken in October, while in 23, 25, 45 and 46 this occurs in July, or rarely August.

From the material available we may conclude that the Varzuga stock is caught mainly in the marine fishing sectors from No. 27 on the west to No. 44 on the east.

[Page 64] For complete information on the abundance of the Varzuga stock, in addition to a fish-enumeration point on the Varzuga River and the tagging work, it would be desirable to organize systematic collections of ichthyological material from the shore fisheries and from other rivers of the Tera coast [the southeastern and eastern coasts of the Kola Peninsula].

Salmon of different rivers put down different numbers of sclerites on their scales up to the time they go to sea. Therefore it is possible that with sufficient collections of material on the structure of the river annuli we would be able to estimate the percentage occurrence of Varzuga fish in fishing sectors more distant from the mouth of the Varzuga.

If, however, it proves impossible to identify Varzuga fish by scale structure, the required picture of abundance of the stocks migrating into rivers of the Tera coast (including the Varzuga) could be obtained only after organization of fish enumeration work on other rivers, particularly the Chavanga, Strelna and Chapoma.

[Permissible rate of exploitation]

At the present time a picture of permissible rates of commercial exploitation can be had only from information on the catches and spawning escapements obtained at the fish enumeration points that have functioned for many years on rivers of Kola Gulf and on the Kolvitsa River. In the years since the war the number of fishing sectors and amount of fishing apparatus has been stabilized; consequently, knowing the abundance of a number of the migrating stocks, and their catch to escapement ratio, we can already know what rate of commercial utilization has established and is maintaining the existing level of abundance of these stocks.

Table 68 gives data on abundance of the stocks in rivers of the Kola Gulf and in the Kolvitsa River, and the changes in percentage commercial utilization.

Table 68 shows that stocks of the Kola Gulf rivers have remained rather stable under exploitations varying from 20% to 30%, while the Kolvitsa stock withstands removals between 33% and 66%. The fact that the Kolvitsa stock supports a higher percentage removal than the Kola rivers cannot be ascribed to a greater reproductive potential, for the average [page 65] fecundity of females in the Kola rivers is considerably higher than the fecundity of the Kolvitsa stock. The situation apparently involves not only natural conditions, but also the fact that prior to the resumption of logging the spawners and young fish were better protected in the Kolvitsa River.

Up to the present the opinion has prevailed among fishermen that there are vast hordes of salmon that ascend the rivers, after eluding all their fishing gear. However the fish enumeration work of Murmangosrybvod has shown clearly that no such hordes exist. In 1958 a total of 1050 fish ascended the Zapadnaia Litsa River, 787 went up the Ura and 6500 up the Tuloma; even the Varzuga — the main salmon producer of the Kola peninsula — had only 20,327 fish. From this it is clear that a rational salmon industry must be developed along the lines of correct utilization of individual stocks on the basis of knowledge of the abundance and replacement potential of each.

Attempts to decide the abundance of stocks from catches can give a more or less correct picture only in years of very large or very small runs. The numerical data for fish that are caught in Kola Strait and Kola Gulf and that have gone up to spawn in its tributary rivers, show clearly the absence of any association between the size of the catch and the escapement, for individual stocks (Table 68).

Various points of view are expressed on questions connected with establishing a norm for rate of commercial utilization, to be used by the fish enumeration points. The average coefficient of return (1:4) which we have obtained for Kolvitsa and Tuloma salmon cannot be regarded as a long-term average. From Tables 57 and 61 it is apparent that the number of spawners entering the river has markedly increased since 1950, while the abundance of the corresponding year-classes increased only very inconsiderably (though the data are still incomplete). It is clear that the average coefficient of return must become considerably less when the several years just ahead are included. I suggest that work on a planned catch and escapement regime could start out with 50% exploitation of the [adult] migrants in any stream whose stock is not depleted and which is not subjected to widespread poaching. According to Krogius and Krokhin [10], with an average [page 66] removal of 56% of the adults the abundance of sockeye in the Ozernaya River increased considerably. According to Nikolsky's [20] data, 64.3% of the population of a pink salmon stock can be utilized, and 54.5% of a chum salmon stock.

Since females commonly make up a larger fraction of a stock of Atlantic salmon than of Pacific, and their average fecundity considerably exceeds that of sockeye, chum and pink salmon, we may consider that utilization of 50% of the run during the first years of operation of a fish enumeration station will not lead to a decrease in abundance of the salmon, provided, of course, that the spawners and young get adequate protection.